

**What Is Claimed Is:**

1. A light emitting diode, comprising:
  - a transparent insulating substrate;
  - a first conductivity type GaN as a first lower cladding layer directly over said transparent insulating substrate;
  - an InGaN light-emitting layer directly over said lower cladding layer;
  - a second conductivity type GaN as second upper cladding layer directly over said InGaN light-emitting layer;
  - a GaN based contact layer with Gallium rich phase and thickness is between 5 Angstroms to 1000 Angstroms directly over said upper cladding layer;
  - an AlGaInSnO system transparent conducting oxide (TCO) as a light transmitting layer directly over said GaN based contact layer, and the thickness of this TCO thin film must over 5 Angstroms;
- 10 15 a first electrode formed on the partially exposed area of the first conductivity type GaN; and  
a second electrode formed on top of the light transmitting layer.
2. A light emitting diode as recited in claim 1, wherein said transparent conducting oxide (TCO) has the composition:
  - 20  $Al_xGa_{3-x-y}In_{5+y}Sn_{2-z}O_{16-2z}$ ,  
Where  $0 \leq x < 2$ ,  $0 < y < 3$ ,  $0 \leq z < 2$ .
  3. A light emitting diode as recited in claim 1, wherein said transparent insulating substrate is selected from a group consisting of  $Al_2O_3$ ,  $LiGaO_2$ ,  $LiAlO_2$  and  $MgAl_2O_4$ .
  - 25 4. A light emitting diode as recited in claim 1, wherein said GaN based

contact layer is selected from a group consisting of AlGaN, GaN, and InGaN.

5. A light emitting diode, comprising:
  - a first conductivity type substrate;
  - 5 a first conductivity type GaN as a first lower cladding layer directly over said substrate;
  - an InGaN light-emitting layer directly over said lower cladding layer;
  - a second conductivity type GaN as a second upper cladding layer directly over said InGaN light-emitting layer;
- 10 a GaN based contact layer with Gallium rich phase and thickness is between 5 Angstroms to 1000 Angstroms directly over said upper cladding layer;
- 15 an AlGaInSnO system transparent conducting oxide (TCO) as a light transmitting layer directly over said GaN based contact layer, and the thickness of this TCO thin film must over 5 Angstroms;
- a first electrode formed underneath the first conductivity type substrate; and
- a second electrode formed on top of the light transmitting layer.

6. A light emitting diode as recited in claim 5, wherein said transparent conducting oxide (TCO) has the composition:

$Al_xGa_{3-x-y}In_{5+y}Sn_{2-z}O_{16-2z}$ ,  
Where  $0 \leq x < 2$ ,  $0 < y < 3$ ,  $0 \leq z < 2$ .
7. A light emitting diode as described in claim 5, wherein said conductivity type substrate is selected from a group consisting of SiC, Si, ZnSe, GaAs, GaP, GaN and AlN.

8. A light emitting diode as described in claim 5, wherein said GaN based contact layer is selected from a group consisting of AlGaN, GaN, and InGaN.
9. A light emitting diode, comprising:
  - 5 a transparent insulating substrate;
  - a first conductivity type GaN as a first lower cladding layer directly over said transparent insulating substrate;
  - an InGaN light-emitting layer directly over said lower cladding layer;
  - a second conductivity type GaN as second upper cladding layer directly
  - 10 over said InGaN light-emitting layer;
  - an AlGaN system intermediate layer directly over said upper cladding layer, with material band-gap energy is lower than the second conductivity type GaN and thickness is between 5 Angstroms to 500 Angstroms;
  - a GaN based contact layer with Gallium rich phase and thickness is
  - 15 between 5 Angstroms to 1000 Angstroms directly over said intermediate layer;
  - an AlGaInSnO system transparent conducting oxide (TCO) as a light transmitting layer directly over said GaN based contact layer, and the thickness of this TCO thin film must over 5 Angstroms;
  - 20 a first electrode formed on the partially exposed area of the first conductivity type GaN; and
  - a second electrode formed on top of the light transmitting layer.
10. A light emitting diode as recited in claim 9, wherein said transparent conducting oxide (TCO) has the composition:
  - 25  $Al_xGa_{3-x-y}In_{5+y}Sn_{2-z}O_{16-2z}$ ,

Where  $0 \leq x < 2$ ,  $0 < y < 3$ ,  $0 \leq z < 2$ .

11. A light emitting diode as recited in claim 9, wherein said transparent insulating substrate is selected from a group consisting of  $\text{Al}_2\text{O}_3$ ,  $\text{LiGaO}_2$ ,  $\text{LiAlO}_2$  and  $\text{MgAl}_2\text{O}_4$ .
- 5    12. A light emitting diode as recited in claim 9, wherein said GaN based contact layer is selected from a group consisting of  $\text{AlGaN}$ ,  $\text{GaN}$ , and  $\text{InGaN}$ .
13. A light emitting diode as recited in claim 9, wherein said intermediate layer is selected from a group consisting of  $\text{AlGaInN}$ ,  $\text{InGaN}$ , and  $\text{InN}$ .
- 10    14. A light emitting diode, comprising:
  - a transparent insulating substrate;
  - a first conductivity type GaN as a first lower cladding layer directly over said transparent insulating substrate;
  - an InGaN light-emitting layer directly over said lower cladding layer;
- 15    a second conductivity type GaN as second upper cladding layer directly over said InGaN light-emitting layer;
  - a GaN based contact layer with Gallium rich phase and thickness is between 5 Angstroms to 1000 Angstroms directly over said upper cladding layer;
- 20    an  $\text{AlGaInSnO}$  system transparent conducting oxide (TCO) as a light transmitting layer directly over said GaN based contact layer, and the thickness of this TCO thin film must over 5 Angstroms;
  - a transparent conducting oxide window layer directly over said light transmitting layer;
- 25    a first electrode formed on the partially exposed area of the first

conductivity type GaN; and

    a second electrode formed on top of the transparent conducting oxide window layer.

15. A light emitting diode as recited in claim 14, wherein said transparent

5    conducting oxide (TCO) has the composition:

$$\text{Al}_x\text{Ga}_{3-x-y}\text{In}_{5+y}\text{Sn}_{2-z}\text{O}_{16-2z},$$

Where  $0 \leq x < 2$ ,  $0 < y < 3$ ,  $0 \leq z < 2$ .

16. A light emitting diode as recited in claim 14, wherein said transparent

insulating substrate is selected from a group consisting of  $\text{Al}_2\text{O}_3$ ,  $\text{LiGaO}_2$ ,

10     $\text{LiAlO}_2$  and  $\text{MgAl}_2\text{O}_4$ .

17. A light emitting diode as recited in claim 14, wherein said GaN based

contact layer is selected from a group consisting of  $\text{AlGaN}$ ,  $\text{GaN}$ , and

InGaN.

18. A light emitting diode as recited in claim 14, wherein said transparent

15    conducting oxide window layer is selected from a group consisting of  $\text{SnO}_2$ ,

$\text{In}_2\text{O}_3$ , ITO,  $\text{Cd}_2\text{SnO}_4$ ,  $\text{ZnO}$ ,  $\text{CuAlO}_2$ ,  $\text{CuCaO}_2$ ,  $\text{SrCuO}_2$ ,  $\text{NiO}$ , and  $\text{AgCoO}_2$ .

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